



# P300 as an auxiliary method in clinical practice: A review of literature

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## ABSTRACT

Cognitive functions can be assessed and followed up over a period of time with cognitive evoked potentials (CEP) P300. In this context, brainstem auditory evoked potentials (BAEP) are most commonly used, but visual evoked potentials (VEP) are utilized as well. The research in this area has demonstrated that these techniques could be used as a supplemental method in diagnostics of numerous diseases such as Alzheimer's disease, mild cognitive impairment, vascular dementia, epilepsy, craniocerebral trauma, Parkinson's disease, multiple sclerosis, and other degenerative diseases. In addition, P300 can also be used as an auxiliary method in the diagnostics of mental disorders conditions such as schizophrenia, panic disorders, narcotic drug addiction, nicotine, alcoholism, etc. The method assists in monitoring the course of diseases leading to encephalopathy, such as liver and kidney damage and grave anaemia. The advantages of P300 testing are easy application, non-invasiveness, and an unlimited number of potential applications. Moreover, the results obtained with this method are measurable and can be compared.

**Keywords:** P300; cognitive; clinical practice

## INTRODUCTION

Neuropsychological tests are applied in assessing cognitive, cortical functions in patients with neurological and mental diseases, brain trauma, and damage resulting from other diseases (1-3). Event-related potential (ERP) is a non-invasive electrophysiological method. It can be used to assess different aspects of human cognitive information processing. ERP components such as auditory evoked P300,

associated with cognitive processes (i.e., attention and orientation), show low amplitude and long latency in acute and chronic diseases (4-6). P300 testing is an unbiased and non-invasive method, standardized for assessing cognitive processes (7-10). We have reviewed the existing literature in this field to better understand the role of P300 testing in diagnostics of different diseases.

## Review of literature

We performed a systematic literature search and review of publications identified in the MEDLINE database (searched through September 2009). The search term was "P300, cognitive", and the search was limited to clinical trials and articles in English.

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The search was extended by the review of bibliographies from pertinent original reports and review articles. The research included 1212 references on P300.

P300 testing has been demonstrated to be a method of choice in differential diagnostic assessment of neurological and psychiatric diseases (Table 1). Clinical research showed significant changes in P300 parameters, such as lowered amplitude and extended latency, in patients with dementia, Alzheimer's disease, and mild cognitive impairment [MCI] (11-19). A smaller number of studies indicated changes in P300 in patients with epilepsy, and in those taking antiepileptic drugs (10,20). A few studies indicated specific changes in amplitude and latency of P300 in clinically isolated syndrome and multiple sclerosis, as well as effects of interferon beta-1b to cognitive functions, even the P300 characteristics (21-23). Some studies indicated changes in P300 characteristics in patients with Parkinson's disease (the changes correlated with the degree of the disease determined according to the Hoehn and Yahr scale), growth hormone deficiency, Huntington's disease, Tourette syndrome, and narcolepsy (2,9,24-27). Changes of P300 characteristics, lowered amplitude, and extended latency

have also been noticed in schizophrenia (28-36), post-traumatic stress disorder (36,37,40), endogenous psychoses (38-41), panic disorder (42-45), and depressive patients (46,47). Additionally, a few papers described changes of P300 in impulsive aggressive criminals and obsessive-compulsive disorder (48,49).

Cognitive damage often results from craniocerebral trauma. The damage and gravity dysfunction are assessed by neuropsychological and neurophysiological analysis, where cognitive evoked potentials (CEP) P300 is among the preferred methods (50-53).

Some studies reported changes in P300 amplitude and latency in cases of chronic consumption of nicotine, alcohol, as well as cannabis, opioids, cocaine, and ecstasy (Table 2) (8,54-60).

Isolated research has been performed on CEP P300 in patients with epilepsy taking different antiepileptic drugs, such as: topiramate, valproate, and lamotrigine (61-63). These studies were based on measuring and comparing CEP P300 parameters while the patients were taking the drugs.

Cognitive damage in some systemic diseases can be assessed with CEP P300 (64-78). Improvements in

**TABLE 1.** Neurological and psychiatric diseases with confirmed changes of P300 wave parameters

| Disease                        | Studies   |
|--------------------------------|---|
| Dementia                       | Uemura et al. (11), Egerházi et al. (17), Egerházi et al. (18)  |
| Alzheimer's disease            | Bennys et al. (12), Juckel et al. (14), Yener et al. (15), van Deursen et al. (16), Egerházi et al. (17), Egerházi et al. (18)  |
| Mild cognitive impairment      | Bennys et al. (12), Golob et al. (13), van Deursen et al. (16), Egerházi et al. (17), Egerházi et al. (18), Pappaliagkas et al. (19)  |
| Epilepsy                       | Zgorzalewicz (10), Ozmenek et al. (20)  |
| Clinically isolated syndrome   | Kocer et al. (21)   |
| Multiple sclerosis             | Magnié et al. (22), Flechter et al. (23)  |
| Parkinson's disease            | Hayashi et al. (24)   |
| Growth hormone deficiency      | Tanriverdi et al. (25), Braverman et al. (26)   |
| Huntington's disease           | Beste et al. (9)  |
| Narcolepsy                     | Saletu et al. (2)   |
| Tourette syndrome              | Thibault et al. (27)  |
| Schizophrenia                  | Ford et al. (28), van der Stelt and Belger (29), Takahashi et al. (30), Zhang et al. (31), Higuchi et al. (32), Wood et al. (33), Özgürdal et al. (1), Sumiyoshi et al. (34), Turetsky et al. (35), Galletly et al. (36), Veltmeyer et al. (37) |
| Endogenous psychoses           | Lebedeva et al. (38), Lebedeva et al. (39), Bramon et al. (40)  |
| Post-traumatic stress disorder | Veltmeyer et al. (37), Shucard et al. (41)  |
| Panic disorder                 | Tuter (42), Gordeev (43), Gordeev (44), Gordeev (45)  |
| Depression                     | Coullaut-Valera García et al. (46), Zhang et al. (47)   |
| Impulsive aggressive behavior  | Zukov et al. (48)   |
| Obsessive-compulsive disorder  | Gohle et al. (49)   |

the treatment and recovery can be followed in the same way. So far, changes in P300 characteristics, amplitude, and latency have been monitored in the following systemic diseases: anaemia, hepatic insufficiency, diabetes mellitus type 1, hypothyroidism, chronic obstructive pulmonary disease (COPD), organophosphorus insecticide poisoning, and HIV-1 neurologically asymptomatic seropositive individuals (Table 3).

DISCUSSION

Cognitive abilities include a number of qualitative characteristics that can be assessed with different neuropsychological tests. Recently, neurophysiological tests with CEP P300 are gaining attention (79-81). During the testing procedure, both auditory and visual stimuli are used. These are referred to as brain-stem auditory evoked potentials (BAEP) and visual evoked potentials (VEP), and BAEP are used more frequently. In addition, comparative analysis of neuropsychological and neurophysiological P300 tests showed a statistically significant correlation, with high specificity and sensitivity (79-83). Changes of CEP P300 are characterized by extended latency and low wave amplitude. Numerous studies showed alterations of CEP P300 in neurological and psychiatric diseases, as well as consequences of traumatic

damages of the brain, that is, craniocerebral injuries (11-53). Different substances that cause addiction, from alcohol and nicotine to various opiates, lead to changes in cognitive functions, including changes in P300 parameters, due to brain damage (54-60). Moreover, with P300 testing, damage of cognitive functions resulting from taking different medicines, especially antiepileptic drugs, can also be monitored (61-63). Additionally, P300 characteristics help diagnosing cognitive damage resulting from systemic diseases, such as anaemia, uremia (renal insufficiency), hepatic encephalopathy, systemic lupus erythematosus, diabetes mellitus, hypothyreosis, as well as COPD (64-76). Moreover, cognitive function damage in patients with HIV-1 neurologically asymptomatic seropositive can be assessed with P300 testing (78). Finally, changes of P300 parameters are observed in organophosphorus insecticide poisoning (77).

CEP P300 tests are easy to apply, can be repeated often, there are no unwanted side effects or radiation, and the application is very simple. Also, the test is unbiased and a tested individual cannot influence the results. The test results (wave amplitude and latency) are expressed numerically. Therefore, the results can be easily compared at various stages of a disease, and the brain damage as well as the healing process can be monitored. All the mentioned above indicate that CEP P300 is a method of choice in differential diagnostics of cognitive functions. This is a preferred supplemental method in diagnostics of cognitive damage in clinical practice.

CONCLUSION

CEP P300 testing is a simple, quantitative, diagnostic method used in diagnosing cognitive damage in

TABLE 2. Substances that cause addiction and results in altered P300

| Addictive substances | Studies                                 |
|----------------------|---|
| Nicotine             | Müller et al. (8), Guney et al. (54)    |
| Alcohol              | Naziel et al. (55), Maurage et al. (56) |
| Cannabis             | Roser et al. (57)                       |
| Opioid               | Singh et al. (58)                       |
| Cocaine              | Gooding et al. (59)                     |
| Ecstasy              | de Sola et al. (60)                     |

TABLE 3. Systemic diseases that cause damage to cognitive functions measurable with P300

| Disease                                       | Studies   |
|---|---|
| Anaemia                                       | Otero et al. (64), Khedr et al. (65), Kececi et al. (66)    |
| Hepatic encephalopathy                        | Reeves et al. (67), Teodoro et al. (68), Guerit et al. (69) |
| Neuropsychiatric systemic lupus erythematosus | Mostafa et al. (70), Buca et al. (71)                       |
| Uremia  | Madan et al. (72)   |
| Diabetes mellitus type 1                      | Cooray et al. (73)  |
| Hypothyroidism                                | Naziel et al. (74), Anjana et al. (75)                      |
| Chronic obstructive pulmonary disease         | Kirkil et al. (76)  |
| Organophosphorus insecticide poisoning        | Dassanayake et al. (77)                                     |
| HIV-1 seropositive subjects                   | Amador Romero et al. (78)                                   |

clinical practice. The main advantage of this method compared to other diagnostic methods is the ability to compare the measurement results easily and to monitor the progress of disease.

## CONFLICT OF INTEREST

The authors declare no conflict of interest.

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